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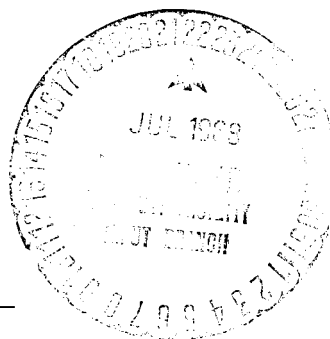
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INVESTIGATION OF THE HYDROXYL (7.2) BAND IN THE TWILIGHT SKY SPECTRUM

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ABSTRACT: An investigation is made of the hydroxyl (7.2) band in the twilight sky spectrum obtained between October, 1964 and January, 1965.

We have already noted [1] that, in the Abastumani Observatory /95* of the Academy of Sciences, Georgian S.S.R., two lines with wavelengths of 6838 and 6867 Å were found in the twilight sky spectrum with the aid of a transmission spectrograph SP-48. We identified them with the *R*- and *Q*- branches of the hydroxyl (7.2) band. The spectrograph was plotted in the spectral range of 5500-6950 Å, which includes only the *R*- and *Q*- branches of the (7.2) band. In October, 1964, the long-wave boundary of this range moved to ~ 7000 Å, which allowed us to obtain the *P*- branch as well as the *R*- and *Q*- branches on the spectrograms. We identified with certainty the radiation lines up to the fourth component of the *P*- branch of the (7.2) band. The components of *P*₅, which have wavelengths of 7005 and 7012 Å, approach the very margin of the spectral sensitivity of the DC film used in the Observatory while carrying out observations according to the IQSY program. Therefore, the components of *P*₅ were not recorded.

Thirteen lines in all were recorded. They corresponded to the components of the OH (7.2) band [2] (Table 1).

TABLE 1

Wavelength, Å	component of the branches of the (7.2) band
6828.5	<i>R</i> ₂
6834.2	<i>R</i> ₁
6842.2	<i>R</i> ₁
6863.9	<i>Q</i> ₁
6878.8	<i>Q</i> ₂
6899.2	<i>P</i> ₁
6898.0	<i>P</i> ₁
6912.0	<i>P</i> ₂
6920.6	<i>P</i> ₂
6939.0	<i>P</i> ₃
6948.5	<i>P</i> ₃
6967.0	<i>P</i> ₄
6976.9	<i>P</i> ₄

In a paper we published earlier [1], we only approximated the wavelengths of the two emissions found. More accurate measurements using a greater number of spectrograms showed that emission of 6838 Å corresponds to the line *R*₁ of 6834.2 Å, and emission of 6867.6 Å corresponds to the *Q* line of 6863.9 Å.

The twilight atmosphere spectra were photographed for six different solar zenith distances during each twilight. However, on the spectrograms taken for zenith distances ≤ 99°, the

* Numbers in the margin indicate pagination in the foreign text.

In analyzing these data, we must consider that the atmospheric absorption bands for oxygen and water are superimposed on the hydroxyl (7.2) band. The segment from 6867.2 to $\lambda = 6880.1 \text{ \AA}$ is occupied by a strong absorption band, and the separate absorption lines, whose wavelengths are shown in Table 2 (according to [3]), are located further away.

We can make the following preliminary observations concerning /98 the data on the line intensities in the OH (7.2) band, shown in Tables 3a, 3b, 3c and 3d.

(1) The Q_3 line of 6878.8 \AA is in the band shown above for strong atmospheric absorption of $6867.2\text{--}6880 \text{ \AA}$. Obviously for this reason, the given line is (on the average) the weakest.

(2) A comparison of the wavelengths shown in Tables 1 and 2 shows that the following radiation lines of the OH (7.2) band coincide with the lines of atmospheric absorption: lines P_1 , 6889.2 \AA , and P_4 , 6976.9 \AA . These two lines also are noticeably weakened, particularly p_1 .

(3) In order to determine the real intensities for separate lines in the band being examined, we must calculate the modifications for absorption given above in Table 2 and Paragraphs 1 and 2. This absorption is determined mainly by the tropospheric vapors of oxygen and water.

(4) The maximum intensities of separate lines are particularly interesting for certain problems. In this relationship, the luminescence of hydroxyl, the (7.2) band, has complex properties, some of which may even seem paradoxical at first glance (see below, Paragraphs 6 and 15).

(5) As the data show, the lines of the (7.2) band collected in Tables 3a, 3b, 3c and 3d occur most frequently in the spectra taken for solar zenith distances $\approx 102\text{--}112^\circ$ (some lines occur in the 24 spectrograms 239 times in all), and less frequently for lesser distances, $100\text{--}102^\circ$ (some lines occur in the 24 spectrograms 85 times in all); for even smaller zenith distances, $99\text{--}100^\circ$, the lines of the (7.2) band occur very rarely: from 24 spectrograms, only two infrequent lines [two on the evening of October 26, 1964 (Table 3a) and four in the morning of January 5, 1965 (Table 3d)] were seen, so that these or other lines occur only 6 times in all. (The values given for the solar zenith distances varied somewhat from day to day; see Tables 3a, 3b, 3c and 3d.)

(6) The intensity of the lines in the (7.2) band is weakest for those zenith distances at which the lines are most frequently recorded, and it is strongest for those at which the lines are most infrequently recorded. This problem is examined in more detail below in Paragraphs 7-13.

(7) For zenith distances $\approx 102-112^\circ$, out of 13 lines in the band being examined the intensity of eight lines reaches, although infrequently, values of 40 or more Rayleighs:

- Line R_k , 6828.5 Å (9 times: 40; 48; 68; 60; 42; 65; 57; 68; 57 Rayleighs - on the average, 56 Rayleighs),

- Line R_1 , 6834.2 Å (6 times: 46; 54; 47; 41; 47; 49 Rayleighs - on the average, 47 Rayleighs),

- Line Q_1 , 6863.9 Å (15 times: 43; 44; 52; 43; 43; 70; 58; 42; 43; 48; 41; 63; 48; 60; 62 Rayleighs - on the average, 51 Rayleighs),

- Line P_2 , 6920.6 Å (3 times: 50; 45; 45 Rayleighs - on the average, 47 Rayleighs),

- Line P_3 , 6939.0 Å (1 time: 40 Rayleighs),

- Line P_3 , 6948.5 Å (4 times: 50; 56; 40; 48 - on the average, 47 Rayleighs), /99

- Line p_4 , 6967.0 Å (2 times: 40; 44 - on the average, 47 Rayleighs),

- Line p_4 , 6976.0 Å (2 times: 50; 40 - on the average, 45 Rayleighs).

(8) These data show that the most intensive lines for solar zenith distances $Z_\odot = 102-112^\circ$ are the following two: R_k , 6828.5 Å (maximum intensity $J_{\max} = 68$ Rayleighs) and Q_1 , 6863.9 Å ($J_{\max} = 70$ Rayleighs). Out of 239 appearances of 13 lines on the 24 spectrograms, the intensity reaches or exceeds 40 Rayleighs in 42 cases (18%), and exceeds 60 Rayleighs only in 6 cases (2.5%).

(9) In the lighter portion of the twilights, when the solar zenith distances are equal to $100-102^\circ$, ten out of thirteen lines reach or exceed 40 Rayleighs:

- R_k , 6828.5 Å (6 times: 80; 60; 78; 73; 106; 82 Rayleighs - on the average, 81 Rayleighs),

- R_1 , 6834.2 Å (1 time: 40 Rayleighs),

- Q_1 , 6863.9 Å (10 times: 81; 78; 108; 64; 115; 75; 60; 83; 100; 83 Rayleighs - on the average, 85 Rayleighs),

- p_1 , 6898.0 Å (1 time: 70 Rayleighs),

- P_1 , 6898.0 Å (5 times: 43; 85; 44; 77; 96 Rayleighs - on the average, 69 Rayleighs),

- p_2 , 6912.0 Å (14 times: 68; 85; 53; 56; 80; 56; 68; 70; 71; 56; 67; 64; 94; 10 Rayleighs - on the average, 70 Rayleighs),

- P_2 , 6920.6 Å (19 times: 40; 68; 96; 82; 110; 56; 72; 107; 78; 78; 104; 68; 102; 106; 77; 50; 65; 67; 105 Rayleighs - on the average, 81 Rayleighs),

- p_3 , 6939 Å (2 times: 74 and 67 Rayleighs - on the average, 70 Rayleighs),

- P_3 , 6948.5 Å (9 times: 78; 70; 113; 50; 105; 108; 64; 86; 129 Rayleighs - on the average, 89 Rayleighs),

- p_4 , 6976.9 Å (5 times: 116; 42; 86; 106; 50 Rayleighs - on the average, 80 Rayleighs).

(10) These data show that the following four lines are most intensive for zenith distances $\cong 100-102^\circ$: R_k , 6828.5 Å ($J_{\max} = 100$ Rayleighs), Q_1 , 6863.9 Å (115 Rayleighs), P_2 , 6920.6 Å (110 Rayleighs), and P_3 , 6948.5 Å (129 Rayleighs). Out of 85 appearances of 13 lines on the 24 spectrograms, the intensity reaches or exceeds 40 Rayleighs in 73 cases (86%), and exceeds 60 Rayleighs in 59 cases (69%), i.e., much more frequently than for solar zenith distances $\cong 102-112^\circ$.

(11) The (7.2) band has the most intense lines for solar zenith distances $\cong 99-100^\circ$, although in this phase of the twilights they were observed only two times out of 14: on the evening of October 26, 1964 (two lines with intensity of 150 and 160 Rayleighs, see Table 3) and on the morning of January 4, 1965 (four lines with intensity of 125-159 Rayleighs, see Table 24).

(12) For zenith distances $\cong 99-100^\circ$, the height of the effective scattering layer $h = 78-90$ km, i.e., it is close to that level on which there is the largest concentration of hydroxyl molecules [4]. It is possible that at zenith distances less than 99° , the intensity of the lines in the (7.2) band is no less than at zenith distances equal to or close to 99° , but it is difficult to find them because of the great intensity of the background of scattered light. We may assume that, if instruments with greater dispersions /100 and resolving power were used, we could detect more intense lines in the (7.2) band for zenith distances even less than 99° .

(13) The dependence of the number and intensity of the lines observed on the solar zenith distances formulated above (see Paragraph 6) gives us the basis on which we can assume that during the period of the twilights ($99^\circ < Z < 112^\circ$), the intensity of the solid spectrum in the portion from 6800 to 7000 Å decreases with an increase in Z more rapidly than the intensity of separate lines in the (7.2) band. This is related to lines Q_1 , 6863.9 Å, p_2 , 6912.0 Å, P_2 , 6920.6 Å and P_3 , 6948.5 Å.

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